Measurement and Verification, Best Practices in Design and Implementation

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ICEBO Conference, Montreal
October 10th, 2013

M&V, Best Practices in Design and Implementation

Presentation Overview

1. Definition of Measurement and Verification (M&V)
2. Applications of M&V
3. Specific M&V Approaches
4. Design – M&V Plan and Specifications
5. Design – Metering and Data Acquisition
6. Design – Project Team Scope
7. Commission – Metering
8. Commission – Data Acquisition
9. Analyze – Project Parameters
10. Analyze – Performance Modelling
11. Analyze – Reporting

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Definition of M&V

"Measurement and Verification is the process of using measurements to reliably determine actual savings"

International Performance Measurement and Verification Protocol - Vol I, 2012

- Types of Savings: Energy, Demand, Emissions, Water

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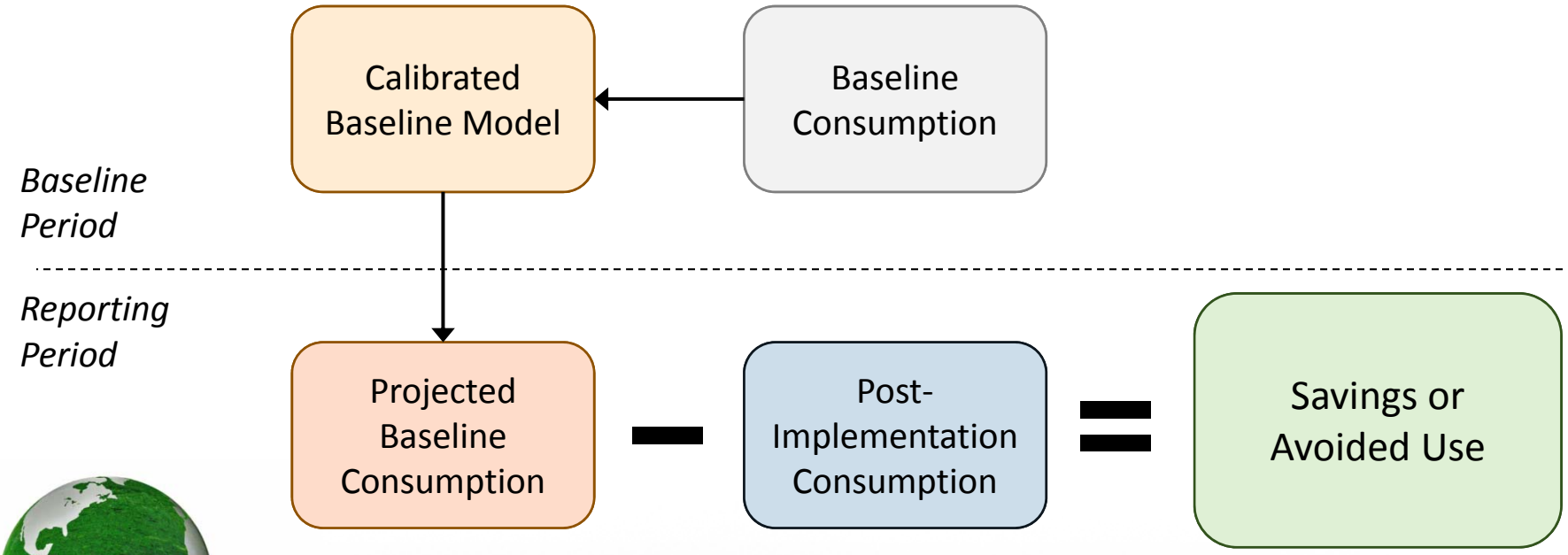
M&V Approaches

The Savings Formula



- Projecting the baseline accounts for changes in facility use, schedules, and weather conditions

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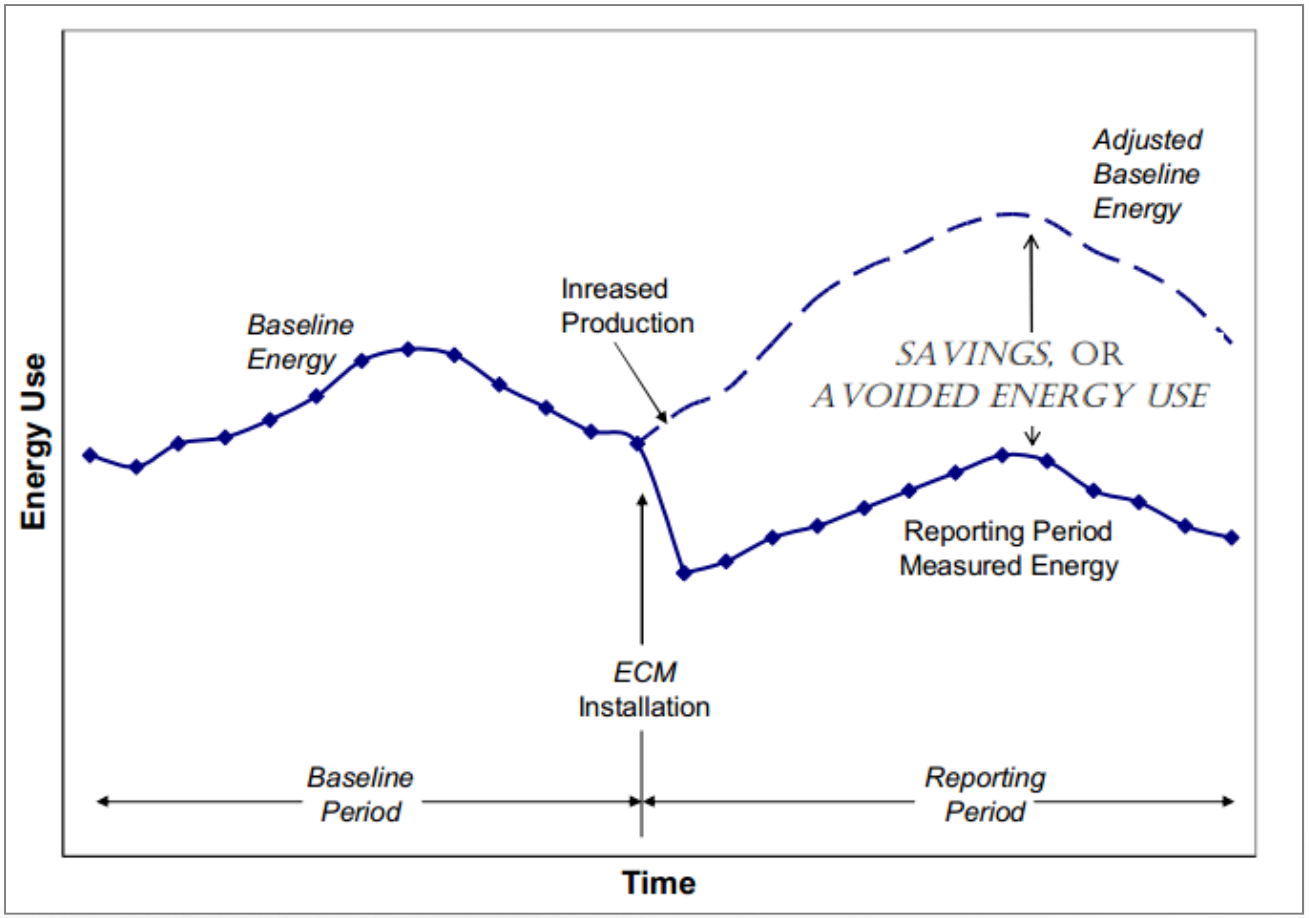
M&V Approaches



IPMVP Vol. 1 2012 – Figure 2

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M&V Applications

When M&V Might be Required:

1. Receiving incentives for Utility or Government savings programs
2. Securing financing for conservation projects
3. Generating and selling carbon offsets
4. Building certification programs
5. Energy management standards (ISO 50001)
6. Performance-based contracts

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M&V Applications

1. **Verify Performance**
   - Return on investments, savings income
   - Savings program performance

2. **Track Performance**
   - On-going facility monitoring

3. **Optimize Performance**
   - Maximize savings of conservation measures

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M&V Approaches

Retrofit Isolation

A – Key Parameter Measurement

- Constant loading or behaviour, minimal interactions
- *E.g. Motor upgrade, exterior lighting retrofit*

B – All Parameter Measurement

- Variable loading or behaviour, or some interactions
- *E.g. Renewable energy, variable-speed drive retrofit*

Whole Building

C – Whole Building Measurement

- Multiple savings measures with interactions
- *E.g. Facility recommissioning with >10% savings*

D – Calibrated Simulation

- No baseline data available
- Savings for individual measures in a group required

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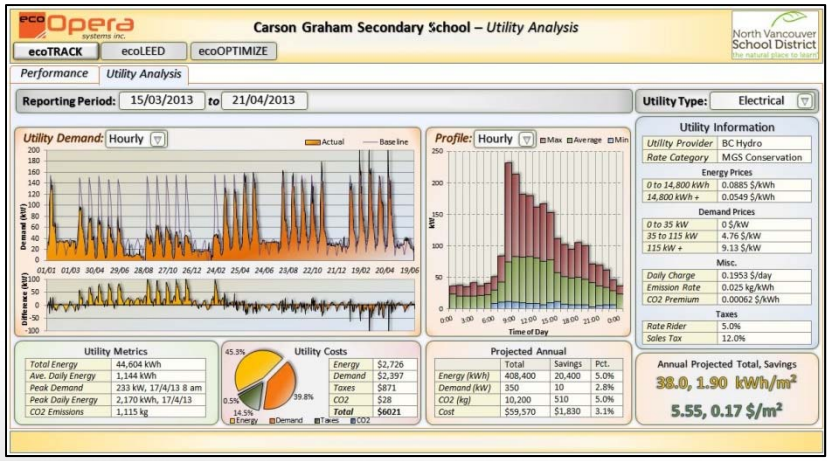
Design – The M&V Plan

Getting the Most from your M&V

In addition to verifying project savings, discuss the requirements or desire for:

1. **Long-Term Performance Tracking**
2. **Facility Performance Benchmarking**
3. **Project Public Education (performance dashboards)**
4. **Sub-Metering of Tenants, End-Use Loads**
5. **Additional Data Archiving**



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Design – The M&V Plan

- M&V should be integrated with a conservation or upgrade program

M&V Plan Contents

1. Summary of conservation measures
2. Required data and measurement boundaries
3. Analysis methodology (baselining, modelling, assumptions, adjustments)
4. Baseline reference period and consumption
5. Operating condition influencing factors (weather, schedules etc.)
6. Reporting period length
7. Meter specifications
8. Expected accuracy of savings estimation

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Design – The M&V Plan

1. **Clarify M&V Outcomes**
   - Design and specify metering devices suited to the application
   - Specify meter and data types (sample products)
2. **Include M&V in Project Specifications**
   - Division 1 – General Requirements (M&V Plan)
   - Division 15/22,23 – Mech., Division 16/26 – Elec., Division 159/25 – Controls
3. **Ensure Quality Control**
   - Require “devices to be commissioned by manufacturer”
   - Include consultant access to Building Automation Systems (BAS)
   - Include allowances for site access during and after retrofits
   - ➢ **Include responsibilities for resolving performance discrepancies**

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Design – Meters and Data

1. **Data Sources**
    i. Utility Bills
    ii. Existing Meters (e.g. equipment onboard monitoring)
    iii. Building Automation System Data
    iv. Short term data logging, or spot measurements
    v. New meter installation

2. **Data Acquisition**
    i. BAS Data Archiving
    ii. 3rd Party Storage (typically through meter manufacturers)
    iii. Energy Management and Information Systems (EMIS), via a dedicated Data Acquisition Server (DAS)

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Design – Meters and Data

How much metering is required for a Whole Building project?

Light

- Utility Bills
- Spot Measurements
- BAS Short-term trends

Medium

Light plus:

- New Central Meters for Primary Consumption
- Meter BAS integration or 3rd party logging

Heavy

Medium plus:

- Sub-meters for major loads and end-uses
- Dedicated data acquisition server
- Long-term archiving of BAS data

➢ Metering requirements depend upon – the acceptable level of uncertainty, the analysis effort required, and the additional M&V desired outcomes

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Design – Project Team Scope

Design/Consultant Phase

- Schematics with meter locations
- Meter specifications
- Meter installation requirements
- Enclosure specification and location
- Data outputs and communication protocols
- DAS power and backup power requirements
- BAS input/output requirements

Construction/Contractor Phase

- Electrical meter installation – currant/voltage transformers connections, display and enclosure mounting
- Thermal, gas meter installation – specific meter location, pipe tapping for meter wells
- Meter communication wiring and BAS integration and configuration
- DAS power and network wiring

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Commission - Meters

General Tasks
- Verify correct installation locations
- Confirm meter shop drawings

Electrical Meter Checks
- CT connections
- CT orientations
- CTs shorted
- Meter power phase
- 3-phase voltage reference
- CT, PT ratios
- Modbus output scaling

Electrical Meter Calibration
- Comparison with utility meter
- Calibrated power meter verification

Gas Meter Checks
- Pulse constants

Gas Calibration
- Comparison with utility meter
- Estimated based on thermal output

Thermal/Flow Meter Checks
- BAS configuration and meter output scaling
- Flow-meter orientation (parallel to pipe)
- Flow-meter upstream, downstream diameters

Thermal/Flow Meter Calibration
- Flow comparison with pump differential pressure and flow-pressure curve
- Redundant temperature sensor comparison
- Temp. sensor water bath calibration

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Commission – Meters